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METHOD AND DEVICE FOR PASSIVELY LOCATING A FIBER STUB IN A GROOVE

RELATED APPLICATIONS

[0005] The present application claims the benefit of priority of copending provisional patent application 60/267,369 filed on 2/8/2001 which is hereby incorporated by reference as if set forth in full.

FIELD OF THE INVENTION

[0010] The invention relates to fiber optic devices, and methods of making fiber optic devices.

BACKGROUND OF THE INVENTION

[0015] In some microoptical assemblies it is necessary to locate a short section (a stub or end, e.g. 0.5-5 mm long) of optical fiber in a groove (e.g. a V-groove). Placing the optical fiber in the groove is a simple matter, but locating the optical fiber longitudinally can be difficult. It would be an advance in the art of microoptical assembly construction to provide a simple method for longitudinally locating an optical fiber stub in a groove such as a V-groove.

SUMMARY OF THE INVENTION

[0020] The invention includes fiber optic device, comprising a substrate comprising at least one groove comprising a first surface, a fiber stop a bonding material, and at least one fiber comprising a second surface in the at least one groove, wherein at least one of the first surface and the second surface has a surface energy that increases in the direction of the fiber stop and method for longitudinally locating an optical fiber stub in a groove wherein the fiber stub is pressed against a fiber stop by surface tension.

DESCRIPTION OF THE FIGURES

[0025] Fig. **1** Shows a side view of an optical fiber in a V-groove and a fiber stop.

[0030] Fig. **2** Shows a top view of an optical fiber in a V-groove and a fiber stop.

[0035] Fig. **3** Shows a partially metallized fiber in a metallized V-groove, being pulled toward a fiber stop by liquid solder surface tension, for one embodiment of the invention.

[0040] Fig. **4** Shows a metallized fiber in V-groove, being pulled toward a metallized fiber stop by liquid solder surface tension, for one embodiment of the invention.

[0045] Figs. **5-7** Show the use of tapered metallization patterns to provide greater wettability toward the direction of the fiber stop, for various embodiments of the invention

[0050] Fig. **8** Shows that increased wettability toward the fiber stop may be achieved by metallization of the end of a fiber, for yet another embodiment of the invention

[0055] Figs. **9 — 12** Show that tapered metallization patterns in a V-groove may be obtained by etching a dry pit that is deeper than a V-Groove. In this way, once metallized, the metal that deposits in the pit will not contribute to solder wetting of the V-Groove.

DETAILED DESCRIPTION

[0060] In the present invention, an optical fiber 1 is longitudinally located in a V-groove 2 in a substrate 3 by surface tension, as can be seen in Figs 1 and 2. A hardenable liquid bonding material e.g. solder, epoxy or the like (not shown), is disposed in the groove 2 with the fiber 1. The fiber 1 may float on the liquid, or the fiber 1 may contact the surfaces of the V-groove 2. Surface tension forces from the liquid pull the fiber 1 in a longitudinal direction. The fiber 1 then butts against a fiber stop 4 such as a vertical sidewall (e.g. from a dicing saw cut). The groove 2 may have wettable and unwettable areas that are shaped to provide surface tension force in a particular direction, such as towards the fiber stop 4. Note that the V-groove 2 can be formed by potassium hydroxide etching of (100) single crystal silicon, as is well known in the art. The etching may be controlled to produce a truncated V-groove, known in the art as a U-groove.

[0065] Figs. 1 and 2 are side and top views respectively of a typical substrate 3 requiring a fiber 1 end (or stub) needing to be butted against the fiber stop 4. Therefore, the fiber 1 needs to be pushed to the right.

[0070] In a preferred embodiment, the optical fiber and groove are metallized and the liquid is solder. Fig. 3 shows an embodiment of the present invention. The fiber 1 is partially metallized 5. The V-groove 2 is fully metallized. Since the fiber 1 is partially metallized 5, the surface tension in the solder fillet 6 tends to push the fiber 1 against the fiber stop 4, the motion providing greater wetted area wetted by solder, thereby providing longitudinal positioning for the optical fiber 1.

[0075] In another aspect of the present invention, as can be seen in Fig. 4, the entire fiber 1 end (but for the face of the fiber) is metallized 7 about its perimeter, and the fiber stop surface 8 is metallized. The longitudinal force on the fiber 1 is provided mainly by the solder fillet 9 attached to the fiber stop surface 8. The fiber stop surface 8 can be metallized by angled metal deposition or sputtering, for example.

[0080] In another aspect of the present invention, the V-groove has a tapered metallization pattern 10, as can be seen in Figs. 5 and 6. The tapered metallization patterns 10 and creates a net surface tension force that pushes the optical fiber 1 toward the fiber stop 4. There is a net force because the taper shape 10 creates a surface that has greater wettability by the molten solder (not shown), by virtue of greater wetted area, toward the direction of the fiber stop 4. In this embodiment, the entire fiber 1 may be metallized. Other tapered metallization patterns can also be used, such as the tapered metallization pattern 11, seen in Fig.7

[0085] In another aspect of the invention, the liquid 12 (e.g. solder) is only present at the fiber stop 4, as shown in Fig. 8. Liquid 12 is not present in the V-groove 2. If solder is used as the liquid 2, the fiber 1 is only metallized (but for the face of the fiber) at the front end 14. The solder fillet 12 at the fiber stop 4 pulls the fiber 1 toward the fiber stop 4.

[0090] In a specific embodiment of the invention, tapered metallization areas can be made by dry etching of the substrate, following by oxidation and wet etching. The process is illustrated in Figs. 9-12. A triangular pit 16 is dry etched in substrate 18. The dry etch can be a high-aspect ratio dry etch process, such as deep reactive ion etching. The pit 16 is conformally coated with a mask layer 20. The mask layer 20 can be a thermal oxidation layer or a silicon nitride CVD layer, for example. The mask layer 20 protects the sidewalls of the dry pit 16. The substrate 18 is masked and a wet etched V-groove 22 is formed. The dry pit 16 is deeper than the V-groove 22. The dry pit 16 has a triangular shape. The V-groove 22 is coated with metal, to form a tapered metallization pattern 24. Optionally, the coating in the dry pit 16 is removed. The dry pit 16 may also be coated with metal, but this will not substantially affect the surface tension forces on a fiber stub (not shown) in the V-groove 22, which in this case will force a fiber (not shown) to the right. Optionally, a dicing saw cut (not shown) may be made distal to the dry pit 16, to provide a vertical fiber stop (not shown).